AU J.T. 16(4): 221-230 (Apr. 2013)

Book Review

A Conceptual Review of "Digital Communication Systems" (Author: Simon Haykin, 2014)

Haykin, S. 2014. Digital Communication Systems.
John Wiley & Sons, Inc., Hoboken, NJ, USA.
Available: <http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP001809.html>.

Dobri Atanassov Batovski

Department of Telecommunications Science, Faculty of Science and Technology
Assumption University, Bangkok, Thailand
E-mail: <dbatovski@au.edu>

The book entitled "Digital Communication Systems", first edition, by Simon Haykin (2014) was published by John Wiley & Sons, Inc., Hoboken, NJ, USA.

It first appeared in January 2013, ©2013, as Wiley E-Text, international standard book number ISBN-13: 978-1-118-54405-1.

The hardcover version of the book was released in February 2013, ©2014, ISBN-13: 978-0-471-64735-5, ISBN-10: 0-471-64735-7.

The book was written by Simon Saher Haykin, McMaster University, Hamilton, Ontario, Canada.

The total number of pages in the book is 800 pages including initial pages (18 pages), 10 chapters (700 pages), 11 appendices A-K (58 pages), glossary (6 pages), bibliography (6 pages), index (10 pages) and credits (2 pages). A blank even page is added at the end of Chapters 2 and 8, appendices A and H, and the Credits (pages 86, 500, A10, A44, and C2) to have an even number of pages.

Earlier books of similar content written by Simon Haykin and published by John Wiley & Sons, Inc., are:

- "Digital Communications", by Simon Haykin, ISBN-13: 978-0-471-62947-4, ISBN-10: 0-471-62947-2, xiv + 597 + 13 blank pages = 624 pages, March 1988, ©1988;

- "Communication Systems", 4th edition, by Simon Haykin, ISBN-13: 978-0-471-17869-9, ISBN-10: 0-471-17869-1, xviii + 816 + 6 blank pages = 840 pages, May 2000, ©2001; and

- "Communication Systems", 5th edition, by Simon Haykin and Michael Moher, Wiley E-Text ISBN-13: 978-0-470-46088-7, November 2008, ©2009, Hardcover ISBN-13: 978-0-471-69790-9, ISBN-10: 0-471-69790-7, xii + 422 + 6 blank pages = 440 pages, March 2009, ©2009.

It should be noted that blank pages at the end of said books are included due to even working with a binding signature having a group of 8 or 16 consecutive pages.

The inclusion of the exact titles of chapters and chapter sections in the series of tables of this book review of Haykin (2014) is made for comparison with Haykin (1988), Haykin (2001), and Haykin and Moher (2009). The main comparison is with Haykin (2001).

A light gray background in some table cells indicates that compared chapter sections are noticeably modified while a significant portion of the content remains the same. A darker gray background highlights chapter sections which are substantially modified or entirely new. The new sections in Haykin (2014) can be easily recognized as the corresponding table cells, allocated for Haykin (2001), are left empty. This visual approach has the advantage of allowing for an effective self-explanatory comparison of the content of the compared books.

Although most chapter sections are not highlighted, they also contain certain textual and graphical updates and additional examples, problems, notes and references. The overall structure, formatting, mathematical notations, etc., in Haykin (2014) appear to be improved for clarity, correctness, and consistency when compared with Haykin (2001).

Table 1. A comparison of the chapter titles in Haykin (1988), Haykin (2001), Haykin and Moher (2009), and Haykin (2014).

Digital Communications (Haykin 1988)	Communication Systems (Haykin 2001)	Communication Systems (Haykin and Moher 2009)	Digital Communication Systems (Haykin 2014)
-	Background and Preview	-	-
1. Introduction	1. Random Processes	1. Prologue	1. Introduction
2. Fundamental Limits on Performance	2. Continuous-Wave Modulation	2. Fourier Theory and Communication Signals	2. Fourier Analysis of Signals and Systems
3. Sampling Process	3. Pulse Modulation	3. Amplitude Modulation	3. Probability Theory and Bayesian Inference
4. Coding Techniques for Analog Signals	4. Baseband Pulse Transmission	4. Phase and Frequency Modulation	4. Stochastic Processes
5. Baseband Shaping for Data Transmission	5. Signal-Space Analysis	5. Random Variables and Processes	5. Information Theory
6. Detection and Estimation	6. Passband Digital Transmission	6. Noise in Analog Modulation	6. Conversion of Analog Waveforms into Coded Pulses
7. Digital Modulation Techniques	7. Spread-Spectrum Modulation	7. Digital Representation of Analog Signals	7. Signaling over AWGN Channels
8. Error Control Coding	8. Multiuser Radio Communications	8. Baseband Transmission of Digital Signals	8. Signaling over Band-Limited Channels
9. Spread Spectrum Communications	9. Fundamental Limits in Information Theory	9. Band-pass Transmission of Digital Signals	9. Signaling over Fading Channels
10. Computer Communications	10. Error-Control Coding	10. Information and Forward Error Correction	10. Error-Control Coding

This book review is conceptual in the sense that it considers the evolution of different topics in digital communication systems and how such topics are presented in a systematic and comprehensive way. The use of tables (Tables 1-12) is essential in viewing an extensive collection of topics so that the changes in the order of appearance of chapters and chapter sections can be easily traced and interpreted.

Table 1 lists the chapter titles in Haykin (1988), Haykin (2001), Haykin and Moher (2009), and Haykin (2014). It shows several tendencies related to:

- transforms;
- probability and statistics;
- information theory;
- analog-to-digital conversion;
- signaling over different channels; and
- error-control coding.

An introduction to transforms (Fourier series, Fourier transform and Hilbert transform) was previously included in appendices (Haykin 1988). However, the content of the appendices changed with the increase of the mathematical complexity in consecutive books as shown in Table 2.

Table 2. List of appendices in Haykin (1988), Haykin (2001), Haykin and Moher (2009), and Haykin (2014).

Digital Communications (Haykin 1988): A. Discrete Fourier Transform B. Properties of the Fourier Transform C. Band-Pass Signals and Systems D. Probability Theory and Random Processes E. Error Function F. Kraft-McMillan Inequality G. Schwarz's Inequality H. Binary Arithmetic
Communication Systems (Haykin 2001): 1. Probability Theory 2. Representation of Signals and Systems 3. Bessel Functions 4. Confluent Hypergeometric Functions 5. Cryptography 6. Tables
Communication Systems (Haykin and Moher 2009): Mathematical Tables
Digital Communication Systems (Haykin 2014): A. Advanced Probabilistic Models B. Bounds on the Q-Function C. Bessel Functions D. Method of Lagrange Multipliers E. Information Capacity of MIMO Channels F. Interleaving G. The Peak-Power Reduction Problem in OFDMA H. Nonlinear Solid-State Power Amplifiers I. Monte Carlo Integration J. Maximal-Length Sequences K. Mathematical Tables.

Table 3. A comparison of Chapter 1 Introduction in Haykin (2014) with Background and Preview in Haykin (2001).

Communication Systems (Haykin 2001): Background and Preview (pp. 1-30, 30 pp.) and Chapter 8 Multiuser Radio Communications, Section 8.2 Multiple-Access Techniques (pp. 513-4)			Digital Communication Systems (Haykin 2014): Chapter 1 Introduction (pp. 1-12, 12 pp.)		
Section	Title	Page number	Section	Title	Page number
-	Historical Notes	26	1.1	Historical Background	1
-	The Communication Process	1	1.2	The Communication Process	2
8.2	Multiple-Access Techniques	513	1.3	Multiple-Access Techniques	4
-	Communication Networks	10	1.4	Networks	6
-	Analog and Digital Types of Communications	21	1.5	Digital Communications	9
-	Preface	vii	1.6	Organization of the Book	11

Similarly, essentials of probability theory and random processes were appended to Haykin (1988) and their placement in Haykin (2001), Haykin and Moher (2009), and Haykin (2014) was affected by book size limitations and conceptual changes.

In relation to book size, Haykin (2014) is most comparable to Haykin (2001). Conceptually, said two books are partial reflections of major technological cornerstones in the development of mobile communications. The second generation (2G) of mobile phone systems reached maturity at the time Haykin (2001) was written, the 2.5G General Packet Radio Service (GPRS) was implemented soon afterwards, and the third-generation (3G) systems were in their infancy. Nowadays, the 3G systems are gradually enhanced by the Long Term Evolution (LTE)-Advanced technology of the fourth generation (4G) systems. Therefore, Haykin (2001) is chosen as a basis for a conceptual comparison with Haykin (2014) in ten tables (Tables 3-12) corresponding to the same number of chapters in both books.

The growing demand for bandwidth was met with a steady development of multiple-access techniques which were implemented in the 3G systems. The importance of this topic is addressed by modifying and moving Section 8.2 from Chapter 8 in Haykin (2001) to become Section 1.3 of the introductory Chapter 1 in Haykin (2014). All sections in said Chapter 1 are shown in Table 3 on a light gray background indicating the inclusion of conceptual updates.

The new material in Chapter 2 deals with the Fourier series and the numerical computation of the Fourier transform (Table 4).

Table 4. A comparison of Chapter 2 Fourier Analysis of Signals and Systems in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Appendix 2 Representation of Signals and Systems (pp. 715-734, 20 pp.) and Chapter 2 Continuous-Wave Modulation (pp. 88-182, 95 pp.)			Digital Communication Systems (Haykin 2014): Chapter 2. Fourier Analysis of Signals and Systems (pp. 13-85, 73 pp.)		
Section	Title	Page number	Section	Title	Page number
-	-	-	2.1	Introduction	13
-	-	-	2.2	The Fourier Series	13
A2.1	Fourier Analysis	715	2.3	The Fourier Transform	16
	Properties of the Fourier Transform (A2.1)	716			
A2.2	Bandwidth	720	2.4	The Inverse Relationship between Time-Domain and Frequency-Domain Representations	25
	Time-Bandwidth Product (A2.2)	721			
	Dirac Delta Function (A2.1)	716	2.5	The Dirac Delta Function	28

Table 4 (Continued).

	Fourier Transforms of Periodic Signals (A2.1)	717	2.6	Fourier Transforms of Periodic Signals	34
	Transmission of Signals through Linear Systems (A2.1)	718	2.7	Transmission of Signals through Linear Time-Invariant Systems	37
	Frequency Response of Linear Time-Invariant Systems (A2.1)	719			
A2.3	Hilbert Transform	723	2.8	Hilbert Transform	42
A2.4	Complex Representation of Signals and Systems	725	2.9	Pre-envelopes	45
	Pre-Envelope (A2.4)	725			
	Canonical Representations of Band-Pass Signals (A2.4)	726	2.10	Complex Envelopes of Band-Pass Signals	47
	Terminology (A2.4)	730	2.11	Canonical Representation of Band-Pass Signals	49
	Band-Pass Systems (A2.4)	730	2.12	Complex Low-Pass Representations of Band-Pass Systems	52
			2.13	Putting the Complex Representations of Band-Pass Signals and Systems All Together	54
	Chapter 2 Continuous-Wave Modulation	88	2.14	Linear Modulation Theory	58
			2.15	Phase and Group Delays	66
-	-	-	2.16	Numerical Computation of the Fourier Transform	69
-	-	-	2.17	Summary and Discussion	78

The inclusion of systematic information about set theory, Bayesian inference, parameter estimation, hypothesis testing, and composite hypothesis testing in Chapter 3 (Table 5) is a timely update. In particular, the Bayesian inference method is crucial for reliable decision making under uncertainty in control systems for mobile communications.

Table 5. A comparison of Chapter 3 Probability Theory and Bayesian Inference in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Appendix 1 Probability Theory (pp. 703-714, 12 pp.) and Chapter 1 Random Processes (pp. 31-87, 57 pp.)			Digital Communication Systems (Haykin 2014): Chapter 3 Probability Theory and Bayesian Inference (pp. 87-144, 58 pp.)		
Section	Title	Page number	Section	Title	Page number
1.1	Introduction		3.1	Introduction	87
-	-	-	3.2	Set Theory	88
A1.1	Probabilistic Concepts	703	3.3	Probability Theory	90
A1.2	Random Variables	708	3.4	Random Variables	97
			3.5	Distribution Functions	98
A1.3	Statistical Averages	711	3.6	The Concept of Expectation	105
	Moments (A1.3) Joint Moments (A1.3)	712 713	3.7	Second-Order Statistical Averages	108
	Characteristic Function (A1.3)	713	3.8	Characteristic Function	111
1.8	Gaussian Process	54	3.9	The Gaussian Distribution	113
	Central Limit Theorem (1.8)	55	3.10	The Central Limit Theorem	118
-	-	-	3.11	Bayesian Inference	119
-	-	-	3.12	Parameter Estimation	122
-	-	-	3.13	Hypothesis Testing	126
-	-	-	3.14	Composite Hypothesis Testing	132
1.15	Summary and Discussion		3.15	Summary and Discussion	133

Table 6. A comparison of Chapter 4 Stochastic Processes in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Chapter 1 Random Processes (pp. 31-87, 57 pp.)			Digital Communication Systems (Haykin 2014): Chapter 4 Stochastic Processes (pp. 145-206, 62 pp.)		
Sec-tion	Title	Page number	Sec-tion	Title	Page number
1.1	Introduction	31	4.1	Introduction	145
1.2	Mathematical Definition of a Random Process	32	4.2	Mathematical Definition of a Stochastic Process	145
1.3	Stationary Processes	33	4.3	Two Classes of Stochastic Processes: Strictly Stationary and Weakly Stationary	147
1.4	Mean, Correlation, and Covariance Functions	35	4.4	Mean, Correlation, and Covariance Functions of Weakly Stationary Processes	149
1.5	Ergodic Processes	41	4.5	Ergodic Processes	157
1.6	Transmission of a Random Process through a Linear Time-invariant Filter	42	4.6	Transmission of a Weakly Stationary Process through a Linear Time-invariant Filter	158
1.7	Power Spectral Density	44	4.7	Power Spectral Density of a Weakly Stationary Process	160
	Relation among the Power Spectral Density and the Magnitude Spectrum of a Sample Function (1.7)	50	4.8	Another Definition of the Power Spectral Density	170
	Cross-spectral Densities (1.7)	52	4.9	Cross-spectral Densities	172
1.9	Noise (Shot Noise)	58	4.10	The Poisson Process	174
1.8	Gaussian Process	54	4.11	The Gaussian Process	176
1.9	Noise	58	4.12	Noise	179
1.10	Narrowband Noise	64	4.13	Narrowband Noise	183
1.11	Representation of Narrowband Noise in Terms of In-Phase and Quadrature Components	64			
1.12	Representation of Narrowband Noise in Terms of Envelope and Phase Components	67			
1.13	Sine Wave Plus Narrowband Noise	69	4.14	Sine Wave Plus Narrowband Noise	193
1.15	Summary and Discussion	75	4.15	Summary and Discussion	195

The chapter on random processes (Chapter 1) in Haykin (2001) becomes a chapter on stochastic processes (Chapter 4) in Haykin (2014) as shown in Table 6. The use of more precise terminology and process classification for strictly stationary and weakly stationary stochastic processes, the addition of another definition of the power spectral density (PSD), the clear interpretation of the Poisson process, and the systematic exposition of narrowband noise are some of the notable improvements in Chapter 4 which contribute to the better understanding of the remaining chapters of the book.

The chapter on information theory (Chapter 5) is beautifully written. The structure of the chapter remains intact (Table 7), except for the omission of Section 9.14 on data compression (Haykin 2001, pp. 614-616) concerned with vector quantizers. Chapter 5 is placed after the chapters on transforms, probability and statistics as a culmination of the fundamental knowledge needed for the proper interpretation of information-theoretic aspects of signaling over communication channels and error-control coding.

Table 7. A comparison of Chapter 5 Information Theory in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Chapter 9 Fundamental Limits in Information Theory (pp. 567-625, 59 pp.)			Digital Communication Systems (Haykin 2014): Chapter 5 Information Theory (pp. 207-266, 60 pp.)		
Section	Title	Page number	Section	Title	Page number
9.1	Introduction	567	5.1	Introduction	207
9.2	Uncertainty, Information, and Entropy	568	5.2	Entropy	207
9.3	Source-Coding Theorem	574	5.3	Source-coding Theorem	214
9.4	Data Compaction	575	5.4	Lossless Data Compression Algorithms	215
9.5	Discrete Memoryless Channels	581	5.5	Discrete Memoryless Channels	223
9.6	Mutual Information	584	5.6	Mutual Information	226
9.7	Channel Capacity	587	5.7	Channel Capacity	230
9.8	Channel-Coding Theorem	589	5.8	Channel-coding Theorem	232
9.9	Differential Entropy and Mutual Information for Continuous Ensembles	593	5.9	Differential Entropy and Mutual Information for Continuous Random Ensembles	237
9.10	Information Capacity Theorem	597	5.10	Information Capacity Law	240
9.11	Implications of the Information Capacity Theorem	601	5.11	Implications of the Information Capacity Law	244
9.12	Information Capacity of Colored Noise Channel	607	5.12	Information Capacity of Colored Noisy Channel	248
9.13	Rate Distortion Theory	611	5.13	Rate Distortion Theory	253
9.15	Summary and Discussion	616	5.14	Summary and Discussion	256

Table 8. A comparison of Chapter 6 Conversion of Analog Waveforms into Coded Pulses in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Chapter 3 Pulse Modulation (pp. 183-246, 64 pp.)			Digital Communication Systems (Haykin 2014): Chapter 6 Conversion of Analog Waveforms into Coded Pulses (pp. 267-322, 56 pp.)		
Section	Title	Page number	Section	Title	Page number
3.1	Introduction	183	6.1	Introduction	267
3.2	Sampling Process	184	6.2	Sampling Theory	268
3.3	Pulse-Amplitude Modulation	188	6.3	Pulse-Amplitude Modulation	274
3.5	Bandwidth-Noise Trade-Off	193			
3.6	Quantization Process	193	6.4	Quantization and its Statistical Characterization	278
3.7	Pulse-Code Modulation	201	6.5	Pulse-Code Modulation	285
3.8	Noise Considerations in PCM Systems	209	6.6	Noise Considerations in PCM Systems	290
3.13	Linear Prediction	223	6.7	Prediction-Error Filtering for Redundancy Reduction	294
3.14	Differential Pulse-Code Modulation	227	6.8	Differential Pulse-Code Modulation	301
3.12	Delta Modulation	218	6.9	Delta Modulation	305
	Line Codes (3.7)	204	6.10	Line Codes	309
3.18	Summary and Discussion	236	6.11	Summary and Discussion	312

The structure of the chapter on conversion of analog waveforms into coded pulses (Chapter 6) is more concise and shortened. As it can be seen from Table 8, several chapter sections from Haykin (2001) are omitted. For example, the section on digital multiplexers (Section 3.10, pp. 214-216) in Haykin (2001) is not included in Haykin (2014). However, additional space for multiple-access techniques is provided in Chapter 9.

Table 9. A comparison of Chapter 7 Signaling over AWGN Channels in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Chapter 5 Signal-Space Analysis (pp. 309-343, 35 pp.), Chapter 6 Passband Data Transmission (pp. 344-478, 135 pp.), and Chapter 9 Fundamental Limits in Information Theory, Section 9.11 Implications of the Information Capacity Theorem, Example 9.11 *M*-ary PSK and *M*-ary FSK (pp. 604-605)			Digital Communication Systems (Haykin 2014): Chapter 7 Signaling over AWGN Channels (pp. 323-444, 122 pp.)		
Sec-tion	Title	Page number	Sec-tion	Title	Page number
5.1	Introduction	309	7.1	Introduction	323
5.2	Geometric Representation of Signals	311	7.2	Geometric Representation of Signals	324
5.3	Conversion of the Continuous AWGN Channel into a Vector Channel	318	7.3	Conversion of the Continuous AWGN Channel into a Vector Channel	332
5.4	Likelihood Functions	322			
5.5	Coherent Detection of Signals in Noise: Maximum Likelihood Decoding	322	7.4	Optimum Receivers Using Coherent Detection	337
5.6	Correlation Receiver	326			
5.7	Probability of Error	328	7.5	Probability of Error	344
6.3	Coherent Phase-Shift Keying	349	7.6	Phase-Shift Keying Techniques Using Coherent Detection	352
6.4	Hybrid Amplitude/Phase Modulation Schemes *M*-ary Quadrature Amplitude Modulation (6.4)	368 369	7.7	*M*-ary Quadrature Amplitude Modulation	370
6.5	Coherent Frequency-Shift Keying	380	7.8	Frequency-Shift Keying Techniques Using Coherent Detection	375
9.11	Implications of the Information Capacity Theorem, Example 9.11 *M*-ary PSK and *M*-ary FSK	604	7.9	Comparison of *M*-ary PSK and *M*-ary FSK from an Information-Theoretic Viewpoint	398
6.6	Detection of Signals with Unknown Phase	403	7.10	Detection of Signals with Unknown Phase	400
6.7	Noncoherent Orthogonal Modulation	407	7.11	Noncoherent Orthogonal Modulation Techniques	404
6.8	Noncoherent Binary Frequency-Shift Keying	413	7.12	Binary Frequency-Shift Keying Using Noncoherent Detection	410
6.9	Differential Phase-Shift Keying	414	7.13	Differential Phase-Shift Keying	411
6.10	Comparison of Digital Modulation Schemes Using a Single Carrier	417	7.14	BER Comparison of Signaling Schemes over AWGN Channels	415
6.14	Synchronization	448	7.15	Synchronization	418
	Recursive Algorithm for Maximum Likelihood Estimation of the Carrier Phase (6.14)	453	7.16	Recursive Maximum Likelihood Estimation for Synchronization	419
6.16	Summary and Discussion	464	7.17	Summary and Discussion	431

An appreciable conceptual change in Haykin (2014) is the emphasis on signaling over different communication channels. This practical approach makes it possible to unite previously separated topics into three consistent chapters. The signaling over additive white noise Gausian (AWGN) channels (Chapter 7) is introduced first (Table 9) which is logical taking into consideration the maximum entropy of the Gaussian distribution and related information-theoretic results introduced in Chapter 5.

Table 10. A comparison of Chapter 8 Signaling over Band-Limited Channels in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Chapter 4 Baseband Pulse Transmission (pp. 247-308, 62 pp.) and Chapter 6 Passband Data Transmission (pp. 344-478, 135 pp.)			Digital Communication Systems (Haykin 2014): Chapter 8 Signaling over Band-Limited Channels (pp. 445-499, 55 pp.)		
Section	Title	Page number	Section	Title	Page number
4.1	Introduction	247	8.1	Introduction	445
4.2	Matched Filter	248	8.2	Error Rate Due to Channel Noise in a Matched-Filter Receiver	446
4.3	Error Rate Due to Noise	253			
4.4	Intersymbol Interference	259	8.3	Intersymbol Interference	447
4.5	Nyquist's Criterion for Distortionless Baseband Binary Transmission	261	8.4	Signal Design for Zero ISI	450
			8.5	Ideal Nyquist Pulse for Distortionless Baseband Data Transmission	450
	Raised-Cosine Spectrum (4.5)	264	8.6	Raised-Cosine Spectrum	454
	Problems, Computer Experiment 4.39	308	8.7	Square-Root Raised-Cosine Spectrum	458
4.11	Computer Experiments: Eye Patterns	293	8.8	Post-Processing Techniques: The Eye Pattern	463
4.10	Adaptive Equalization	287	8.9	Adaptive Equalization	469
	Comparison of Digital Subscriber Lines and Voiceband Modems (6.13)	446	8.10	Broadband Backbone Data Network: Signaling over Multiple Baseband Channels	474
4.8	Digital Subscriber Lines	277	8.11	Digital Subscriber Lines	475
6.12	Multichannel Modulation, Capacity of AWGN Channel (6.12)	431	8.12	Capacity of AWGN Channel Revisited	477
	Continuous-Time Channel Partitioning (6.12)	432	8.13	Partitioning Continuous-Time Channel into a Set of Subchannels	478
	Water-Filling Interpretation of the Optimization Problem (6.12)	438	8.14	Water-Filling Interpretation of the Constrained Optimization Problem	484
6.13	Discrete Multitone, DFT-Based DMT System (6.13)	440 444	8.15	DMT System Using Discrete Fourier Transform	487
6.16	Summary and Discussion	464	8.16	Summary and Discussion	494

The chapter on signaling over band-limited channels (Chapter 8) is introduced next. Table 10 shows the chapter sections about baseband pulse transmission and passband data transmission in Haykin (2001) which are combined to form Chapter 8. The conceptual emphasis is on digital subscriber lines (DSLs), asymmetric DSL (ADSL) and very-high-bit-rate DSL (VDSL), with the application of discrete multitone (DMT) techniques over twisted-wire pairs and the practical use of discrete Fourier transform (DFT). Inverse DFT is performed at the transmitter and DFT at the receiver with an efficient implementation of the fast Fourier transform (FFT) algorithm so that the block length N of the number of subchannels is an integer power of 2.

Sections 8.6, 8.7, 8.10, 8.13, and 8.14 in Chapter 8 are formed from subsections and computer experiments in Haykin (2001) as shown in Table 10. Also, some sections in Haykin (2001) are reduced to problems in Haykin (2014) or omitted. The extensive information on correlative-level coding in Section 4.6 (Haykin 2001, pp. 267-275) concerned with duobinary and modified duobinary codes is only briefly mentioned in Problems 8.10 and 8.11 (pp. 496-497) in Haykin (2014). The description of baseband M-ary pulse-amplitude modulation (PAM) in Section 4.7 (Haykin 2001, pp. 275-277) is omitted and superseded by M-ary quadrature amplitude modulation (QAM) in Section 7.7 (Haykin 2014).

Table 11. A comparison of Chapter 9 Signaling over Fading Channels in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Chapter 6 Passband Data Transmission (pp. 344-478, 135 pp.), Chapter 7 Spread-Spectrum Modulation (pp. 479-511, 33 pp.) and Chapter 8 Multiuser Radio Communications (pp. 512-566, 55 pp.)			Digital Communication Systems (Haykin 2014): Signaling over Fading Channels (pp. 501-576, 76 pp.)		
Sec-tion	Title	Page number	Sec-tion	Title	Page number
8.1	Introduction		9.1	Introduction	501
8.5	Wireless Communications, Propagation Effects (8.5)	532	9.2	Propagation Effects	502
-	-	-	9.3	Jakes Model	506
8.6	Statistical Characterization of Multipath Channels	535	9.4	Statistical Characterization of Wideband Wireless Channels	511
-	-	-	9.5	FIR Modeling of Doubly Spread Channels	520
8.7	Binary Signaling over a Rayleigh Fading Channel	542	9.6	Comparison of Modulation Schemes: Effects of Flat Fading	525
8.7	Binary Signaling over a Rayleigh Fading Channel, Diversity Techniques (8.7)	544	9.7	Diversity Techniques	527
-	-	-	9.8	"Space Diversity-on-Receive" Systems	528
-	-	-	9.9	"Space Diversity-on-Transmit" Systems	538
-	-	-	9.10	"Multiple-Input, Multiple-Output" Systems: Basic Considerations	546
-	-	-	9.11	MIMO Capacity for Channel Known at the Receiver	551
6.13	Discrete Multitone, Orthogonal Frequency Division Multiplexing (6.13)	447	9.12	Orthogonal Frequency Division Multiplexing	556
7.3	A Notion of Spread Spectrum	488	9.13	Spread Spectrum Signals	557
7.5	Signal-Space Dimensionality and Processing Gain	493			
7.7	Frequency-Hop Spread Spectrum	499			
8.2	Multiple-Access Techniques	514	9.14	Code-Division Multiple Access	560
7.8	Computer Experiments: Maximal-Length and Gold Codes	505			
8.8	TDMA and CDMA Wireless Communication Systems, RAKE Receiver (8.8)	549	9.15	The RAKE Receiver and Multipath Diversity	564
8.11	Summary and Discussion	559	9.16	Summary and Discussion	566

The signaling over fading channels (Chapter 9) is included in the third and final chapter on signaling techniques. Chapter sections related to passband data transmission, spread-spectrum modulation and multiuser radio communications in Haykin (2001) are combined under the topic of space diversity in Haykin (2014) as shown in Table 11. Chapter 9 contains substantial modifications and additions such as an introduction to the Jakes model for fast fading channels, finite-direction impulse response (FIR) modeling of doubly spread channels, multiple-input multiple-output (MIMO) systems, and code-division multiple access (CDMA). Orthogonal frequency division multiple access (OFDMA) and CDMA are further considered as dominant multiple access approaches for wireless communications. A description of the RAKE receiver in relation to CDMA is also included.

Table 12. A comparison of Chapter 10 Error-Control Coding in Haykin (2014) with similar content in Haykin (2001).

Communication Systems (Haykin 2001): Chapter 10 Error-Control Coding (pp. 626-702, 77 pp.)			Digital Communication Systems (Haykin 2014): Chapter 10 Error-Control Coding (pp. 577-700, 124 pp.)		
Sec-tion	Title	Page number	Sec-tion	Title	Page number
10.1	Introduction	626	10.1	Introduction	577
			10.2	Error Control Using Forward Error Correction	578
10.2	Discrete-Memoryless Channels	629	10.3	Discrete Memoryless Channels	579
10.3	Linear Block Codes	632	10.4	Linear Block Codes	582
10.4	Cyclic Codes	641	10.5	Cyclic Codes	593
10.5	Convolutional Codes	654	10.6	Convolutional Codes	605
			10.7	Optimum Decoding of Convolutional Codes	613
10.6	Maximum Likelihood Decoding of Convolutional Codes	660	10.8	Maximum Likelihood Decoding of Convolutional Codes	614
			10.9	Maximum a Posteriori Probability Decoding of Convolutional Codes	623
			10.10	Illustrative Procedure for MAP Decoding in the Log-Domain	638
			10.11	New Generation of Probabilistic Compound Codes	644
10.8	Turbo Codes	674	10.12	Turbo Codes	645
10.9	Computer Experiment: Turbo Decoding	682			
			10.13	EXIT Charts	657
10.10	Low-Density Parity-Check Codes	683	10.14	Low-Density Parity-Check Codes	666
10.11	Irregular Codes	691			
10.7	Trellis-Coded Modulation	668	10.15	Trellis-Coded Modulation	675
			10.16	Turbo Decoding of Serial Concatenated Codes	681
10.12	Summary and Discussion Notes and References 694 Problems 696	693	10.17	Summary and Discussion	688

The last chapter in Haykin (2014) is on error control coding (Chapter 10). It has 124 pages compared to 77 pages in Haykin (2001) as shown in Table 12. The chapter retains its previous content except for some short subsections. For instance, automatic-repeat request (ARQ) in the Introduction (pp. 628-629) in Haykin (2001) is only briefly mentioned in the Notes on page 698 in Haykin (2014). The substantial additions to the chapter are concerned with the decoding of convolutional codes and turbo codes. Section 10.7 is dedicated to the optimum decoding of convolutional codes. Section 10.9 describes three different maximum-a-posteriori-probability (MAP) decoding algorithms for convolutional codes: the Bahl, Cocke, Jelinek, and Raviv (BCJR) algorithm, the log-MAP-algorithm, and the max-log-MAP algorithm. The MAP decoding is essential in order to gain an understanding of the principle of operation of turbo codes introduced in Section 10.12. Section 10.10 includes an example of the decoding of a recursive systematic convolutional (RSC) code with the use of the max-log-MAP algorithm. After introductory remarks in Section 10.11 on probabilistic compound codes, Section 10.13 discusses extrinsic information transfer (EXIT) charts and Section 10.16 explains the turbo decoding of serial concatenated codes. Section 10.14 on low-density parity-check (LDPC) codes is somewhat short as before but Haykin appropriately redirects the reader to alternative sources.